



International Center for Tropical Agriculture
Since 1967 *Science to cultivate change*

New forage germplasm to improve the productivity and quality of biomass

Tropical pastures in a changing environment: development of an international research collaboration in Latin America and the Caribbean. *Turrialba, April 24th, 2019*

Mauricio Sotelo and Michael Peters and Chirs Jones

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RESEARCH PROGRAM ON
Climate Change,
Agriculture and
Food Security

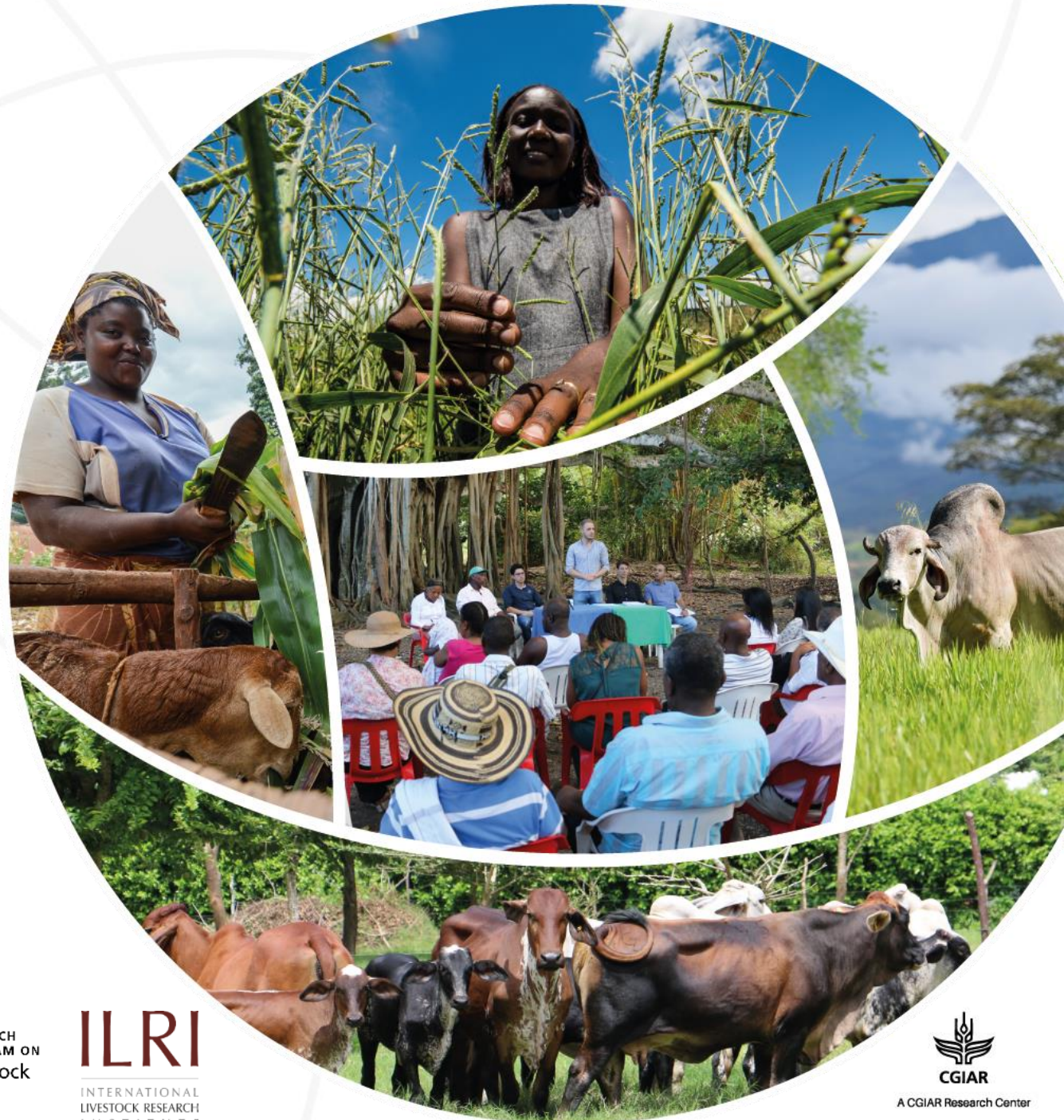


RESEARCH
PROGRAM ON
Livestock

ILRI
INTERNATIONAL
LIVESTOCK RESEARCH
INSTITUTE



A CGIAR Research Center



Regions





Conserving the world's largest collections of beans, cassava, and tropical forages



37,987

Bean
accessions



6,643

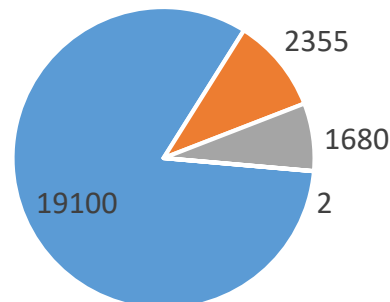
Cassava
accessions



44,000

Tropical forage
accessions

Agrobiodiversity is **key** to maintaining ecosystems and providing adequate supplies of **healthy, nutritious food** in the face of climate change & environmental degradation.



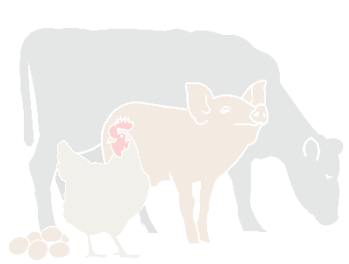
- Herbaceous legumes
- Shrub legumes
- Grasses
- Others

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Building a sustainable future



Why are Livestock and forages important: The facts



17
BILLION

The estimated total number of livestock worldwide

(including cattle, sheep, goats, and about a dozen lesser known guinea fowl, yaks, and

About two-thirds of the world's total agricultural area

4.9 Bha

is used to feed livestock, including

The value of livestock as a global asset reaches



USD3.1
TRILLION

that accounts for some

3 Billion jobs

Grazed livestock systems are the world's single biggest land use. So, how they're managed – and especially how they're fed – is profoundly important for people and the planet



~200 Million

In America Latina alone, have been degraded by overgrazing and other unsustainable production practices.

This negative impact is similar in most areas used for feed 70% of sweet water to agriculture, 22% to livestock



livestock to climate change, which is about

8.1 billion tCO₂eq

These includes emissions from deforestation to make way to pastures.

Of total agricultural emissions

15%

of all human-induced greenhouse gas emission

Importance of high nutritional quality and productivity forages for the tropics



LivestockPlus - the sustainable intensification of forage-based systems

Rao et al., 2015. DOI: [10.17138/TGFT\(3\)59-82](https://doi.org/10.17138/TGFT(3)59-82)

Three innovative/ intensification processes:



GENETIC

Improved yield, quality,
stress resistance



ECOLOGICAL

Better management of
mixed crop-forage-tree-
livestock systems



SOCIOECONOMIC

Creation of enabling
environments (markets,
policies, social & human
capital)

Livelihood benefits:



FOOD

and nutrition
security



MANURE

Organic
fertilizers



ADAPTATION

To climate
change



INCOME

Generation



POVERTY

Alleviation

Ecosystem services

- Resource use efficiency
- Restoration of degraded lands
- Reduced per unit animal GHGs
- Mitigation of climate change
- Biodiversity conservation
- Water flows and quality
- Reduced erosion & sedimentation
- Reduce pressure to the forest – Reduce deforestation

Colombian Forages Network

Cooperation between National Agricultural Research System (Agrosavia) and CIAT.

Grasses		
Gender	Origin	# accessions
<i>Brachiaria</i> spp (Syn <i>Urochloa</i> spp)	CIAT	80
<i>Panicum máximum</i> (Syn <i>Megathyrsus máximus</i>)	CIAT	130
<i>Chloris gayana</i>	ILRI	20
<i>Andropogon gayanus</i>	CIAT	2
<i>Cenchrus ciliaris</i>	ILRI	15
<i>Paspalum</i> spp	CIAT	30
<i>Pennisetum</i> sp	ICA-Cuba	3

Total 425 accessions

Legumes		
Gender	Origin	# accessions
<i>Leucaena</i> spp	CIAT	15
<i>Clitoria</i> spp	CIAT	30
<i>Cajanus cajan</i>	CIAT/ ICRISAT	75
<i>Cratylia argentea</i>	CIAT	5
<i>Arachis pintoii</i>	CIAT	5
<i>Desmodium heterocarpon</i> , <i>Desmodium velutinum</i>	CIAT	5
<i>Centrocema molle</i> , <i>Centrosema macrocarpum</i>	CIAT	10

Agronomic Evaluation of *Chloris gayana*

- Select the materials with the best agronomic performance and forage production based on dry matter in the maximum and minimum precipitation period.
- Location and type of soil: CIAT- Palmira - sandy loam soils.

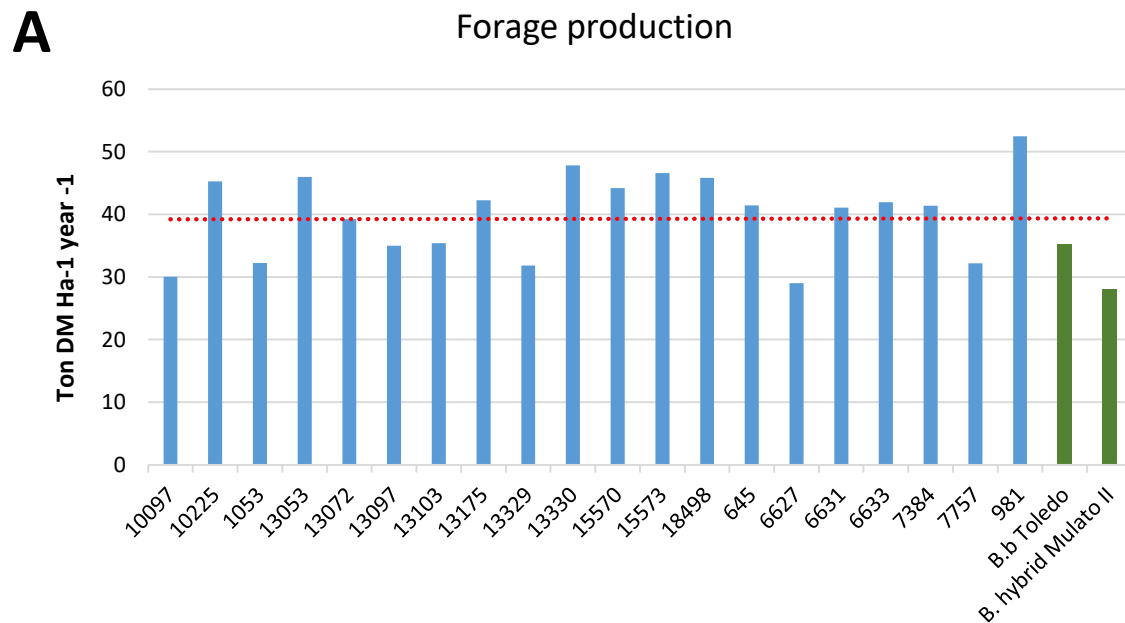
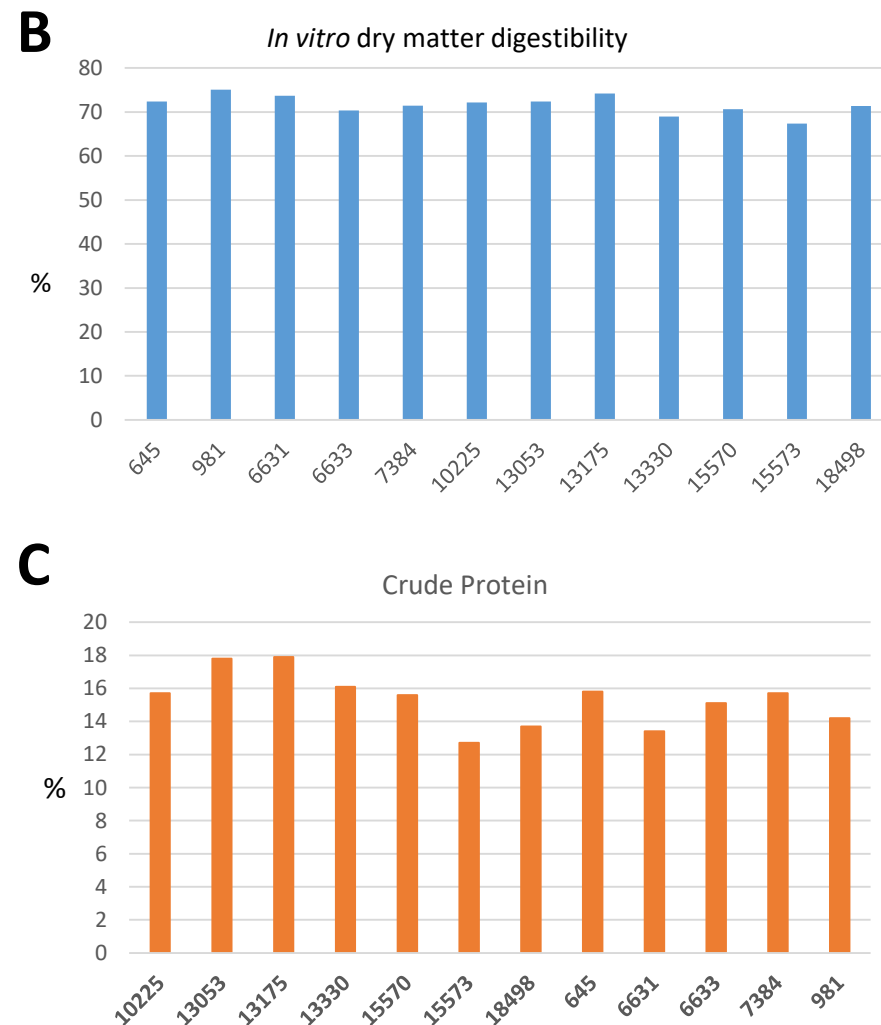


Figura 2. A. 1. Dry matter productivity of 20 accessions of *Chloris gayana* after 6 week of regrowth in wet and dry season (mean of two cuts). **B.** *In vitro* dry matter digestibility. **C.** Crude protein content of accessions that exceeded the productivity threshold of 40 Tons DM Ha⁻¹ year⁻¹



Agronomic Evaluation of *Cenchrus ciliaris*

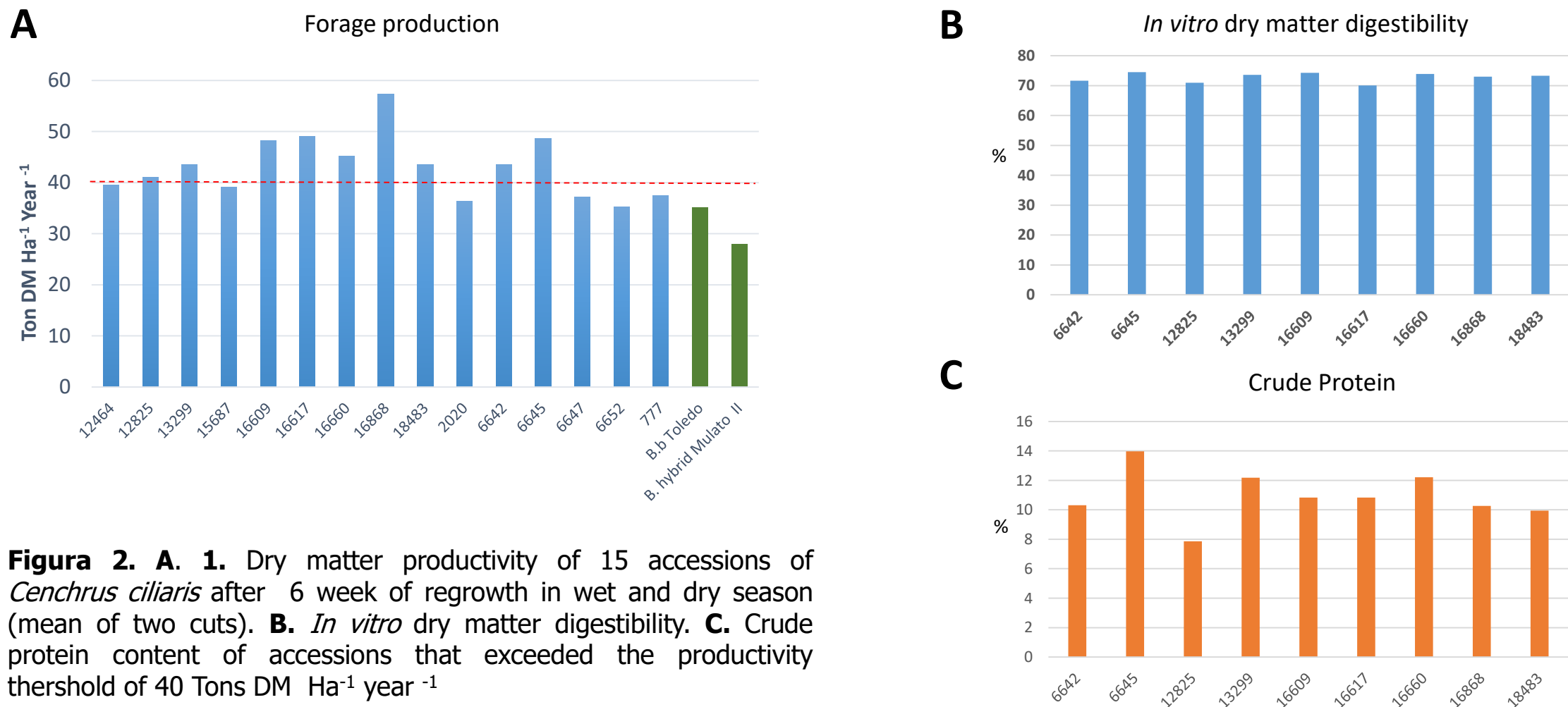


Figura 2. A. 1. Dry matter productivity of 15 accessions of *Cenchrus ciliaris* after 6 week of regrowth in wet and dry season (mean of two cuts). **B.** *In vitro* dry matter digestibility. **C.** Crude protein content of accessions that exceeded the productivity threshold of 40 Tons DM Ha⁻¹ year⁻¹

Options currently being evaluated for the tropics

ILRI (Dryland areas)

***Chloris gayana* (Rhodes)**

- A major forage in the tropics and subtropics.
- Cross-pollinating C4, with diploid and tetraploid forms, usually propagated by seed
- Known for its wide adaptability and ease of establishment

***Cenchrus ciliaris* (Buffel)**

- One of the best pasture grasses for the Africa subtropics
- An apomictic, perennial C4 grass
- Good forage potential, and particularly a candidate for drought tolerance
- Also helps to prevent soil erosion

***Pennisetum pedicellatum* (Desho)**

- Well adapted and widely used in the highlands Ethiopia along with natural resource management practices
- It is a source income through sale of cut forage and planting material

Jones & Sartie. 2018

Forages Breeding



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Improving the livelihoods of poor crop-livestock farmers in the tropics

1. Intensifying PRODUCTION while reducing the ENVIRONMENTAL FOOTPRINT

ADAPTATION to secure:



Animal **NUTRITION**



TOLERANCE to drought and waterlogging

MITIGATION



Reductions of **methane**/unit livestock product



Biological **Nitrification** Inhibition



GHG sequestration

CLIMATE CHANGE EFFECTS

2. An UNIQUE breeding program, which generates

Apomictic *Brachiaria* and *Panicum* hybrids for the tropics adapted to stresses:

BIOTIC



Spittlebug pest



Rhizoctonia foliar blight

ABIOTIC



Soil acidity



Water scarcity



Water excess



In **2001** the first apomictic hybrid was released



To date, **6 apomictic hybrids** are available in the market.

3. Building the NEXT GENERATION hybrids for floodable regions



Cardoso et al (2013)

Brachiaria humidicola has a potential sowing area of

6,300,000 km²

in tropical Latin America only



(That equals the whole area of these 8 countries)

For the new releases we are integrating:



Improving

NUTRITIONAL QUALITY

Better nitrogen use, by reducing



Nitrate leaching



Nitrous oxide emissions

Ability to improve soil health
Reversing and avoiding soil degradation



5. The need to INVEST in additional modernization efforts was also identified



Breeding Program Assessment Tool
maximizing genetic gain
(Extract from BPAT review implemented on May 2018)



End-to-end mechanization systems



Data management



Stable long-term investment

4. Based on our STRENGTHS

(Extract from BPAT review implemented on May 2018)



High throughput testing methods for speed up spittlebug assays and scoring apomictic plants.



Speed approaches implemented to **reduce breeding cycle time**.



Strong **partnerships** and **collaboration** with NARS and private sector.

SUCCESSFUL RELEASES

20,000 smallholder farmers

in **Africa** have already planted CIAT-bred *Brachiaria* hybrids, and the estimated potential is

2 MILLION hectares

In **Latin America**, have been sown on over

930,000 ha by 2018.

Current breeding programs



Interspecific – *Brachiaria*
(syn. *Urochloa*)
(*decumbens* / *brizantha* /
ruziziensis)
1990



Brachiaria humidicola
(syn. *Urochloa humidicola*)
2006



Panicum maximum
(syn. *Megathyrsus maximus*)
2016

Focusing on guarantee effectiveness and therefore adoption, and launch products with optimum performance under **real farmers conditions**.

Commercial releases of forage hybrids

CIAT has released more than

200

advanced genotypes, out of those

Four are already commercialized, and Four are in development and adaptation.

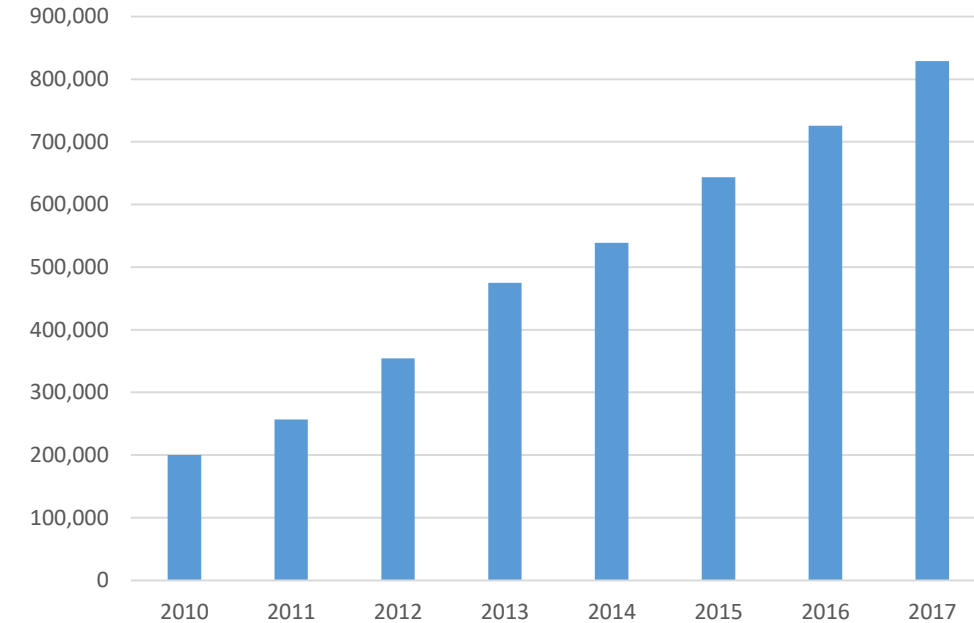


Mulato, the first commercial Brachiaria hybrid (released in **2001**) was bred by CIAT.

**Estimated by seed sales, assuming 7 kilos of seed per hectare (2017)*



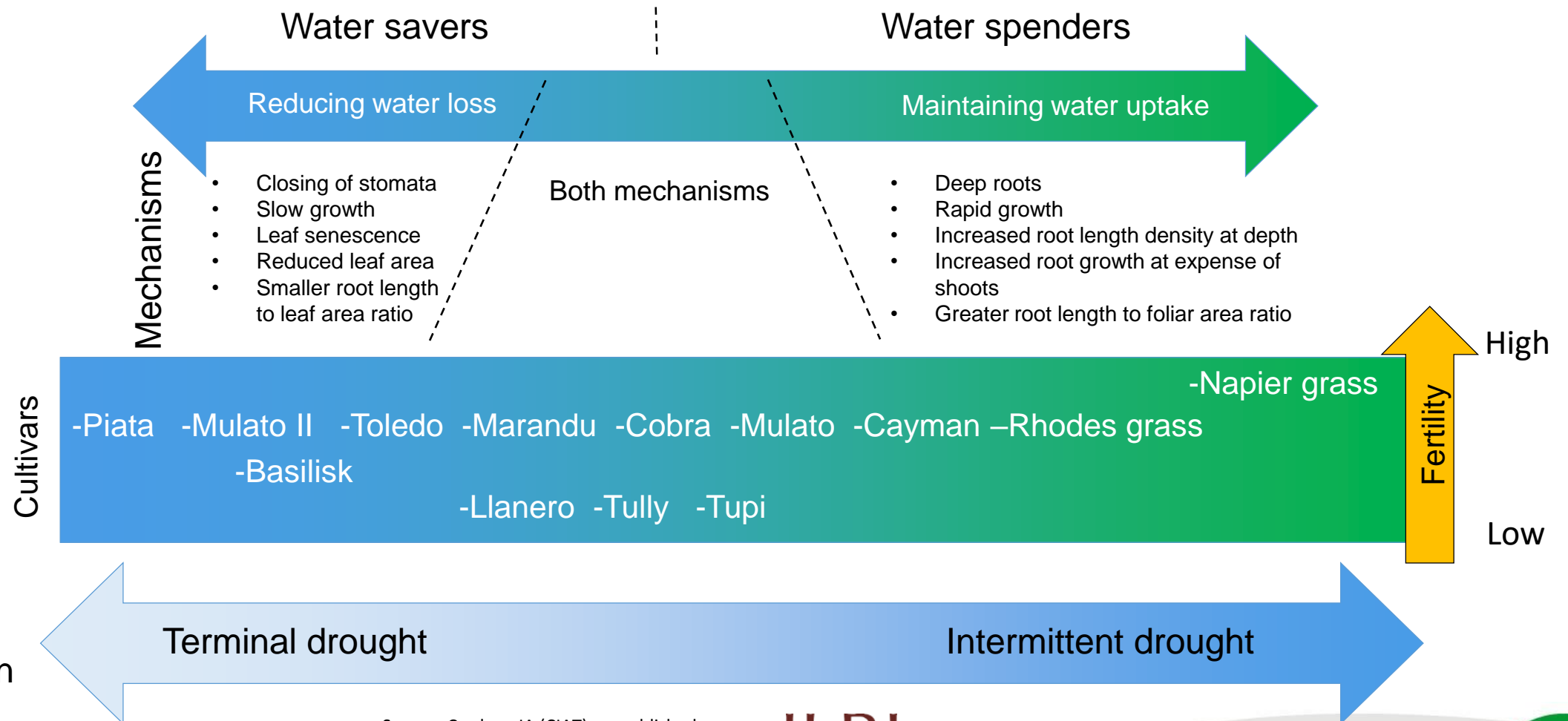
CIAT Brachiaria hybrids planted globally in ha



Hybrids has been a success in the market, reaching a total area of **828,638** ha*

Phenotyping / detection of drought resistance (high performance)

Targeting of Brachiaria grasses to areas with different patterns of drought



Source: Cardoso JA (CIAT), unpublished

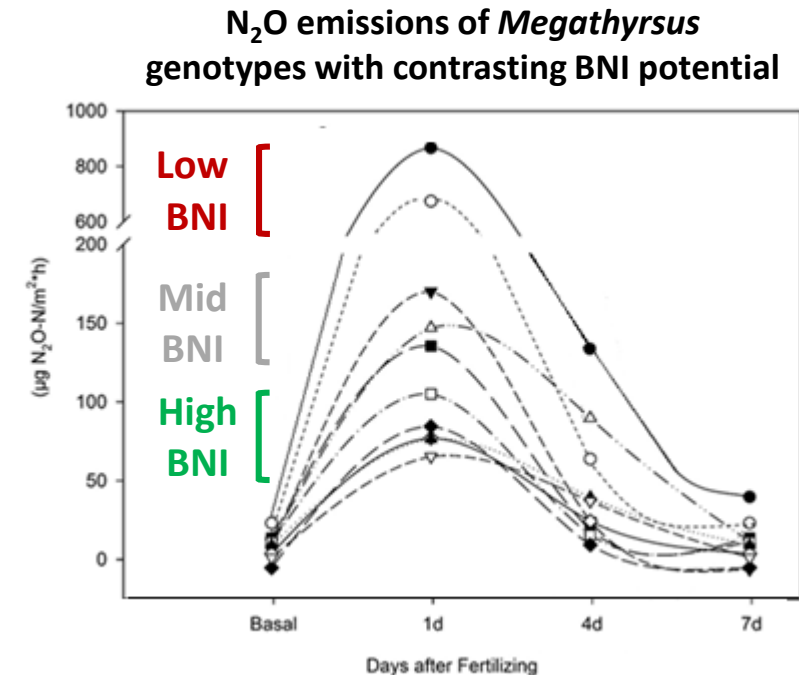
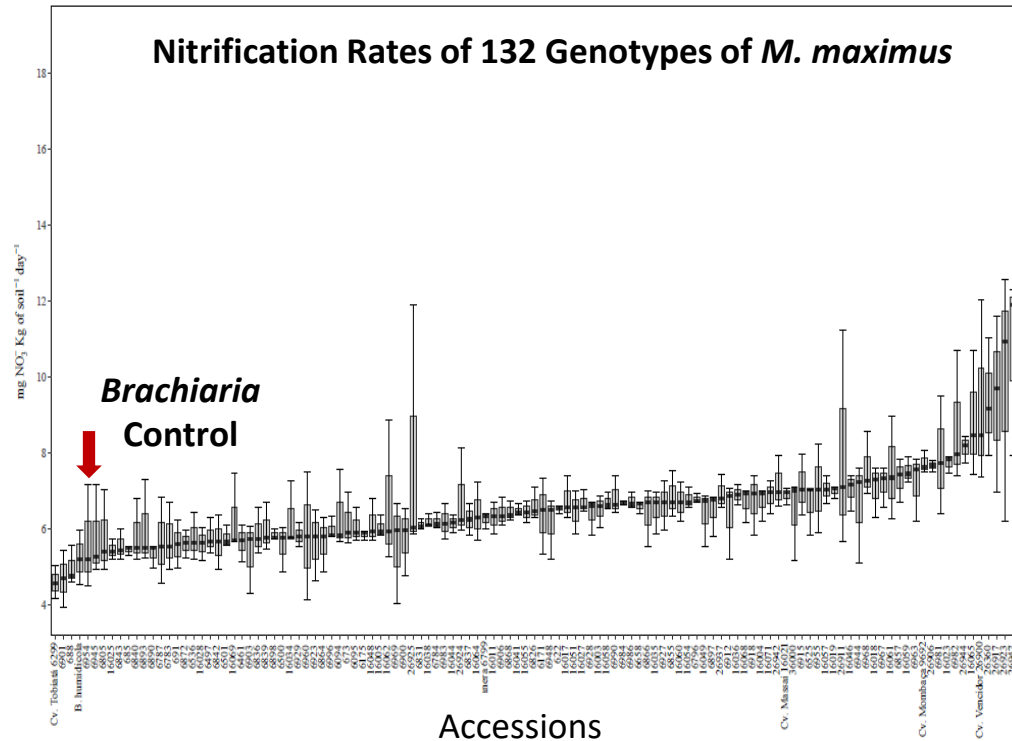
BNI Potential of *Megathyrus maximus*

Why *Megathyrus*? → Key for sustainable intensification (superior biomass and quality)

Goal: To evaluate the BNI potential of different *Megathyrus* genotypes for its implementation in a plant breeding



132 *M. maximus* accessions
Bh CIAT 16888 (+)
Bare Soil (-)



- ✓ *Megathyrus* genotypes with higher BNI capacity than *Brachiaria* were identified.
- ✓ Achieving reduction of N₂O emissions up to 84 % (vs. 55 % of Bh) compared to low BNI accessions.

Silvopastoral test at CIAT to evaluate the productive and environmental parameters with combinations of grasses and legumes

Polytunnels with capacity for simultaneous measurement of CH₄ of four animals

Treatments:

T1: *Brachiaria* hybrid cv Cayman.

T2: *Brachiaria* hybrid cv Cayman + *Canavalia brasiliensis*.

T3: *Brachiaria* hybrid cv Cayman + *Canavalia brasiliensis* + *Leucaena diversifolia*.

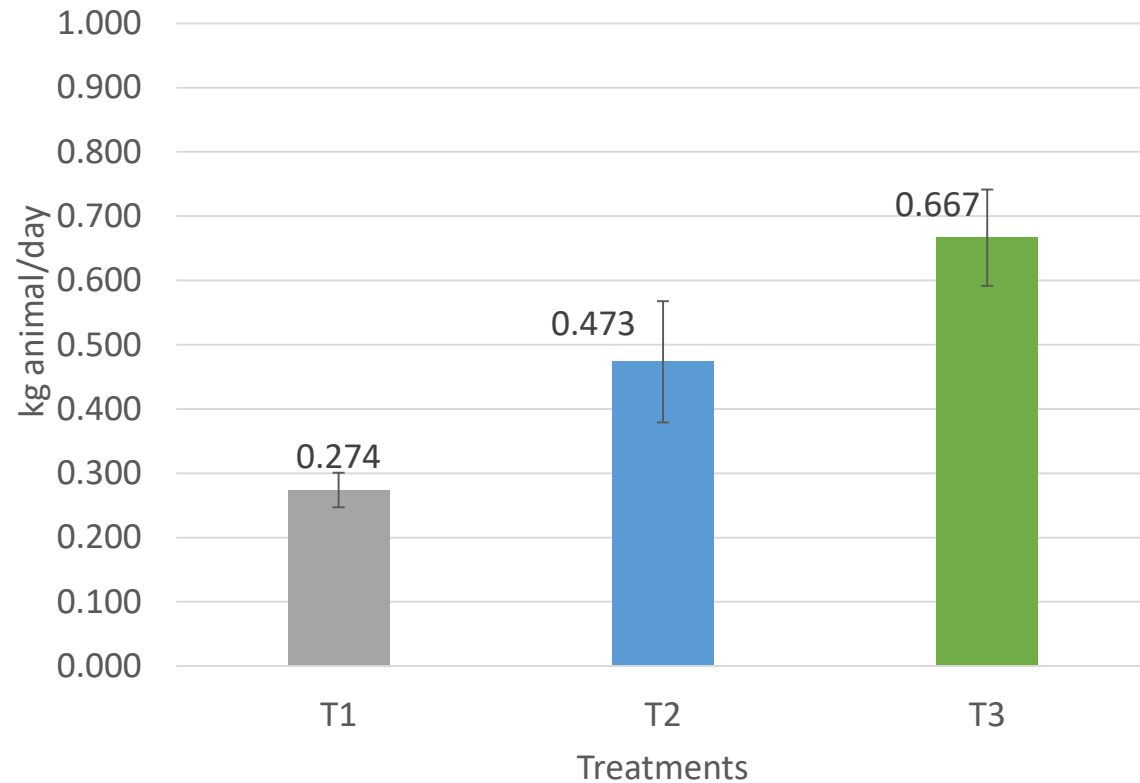


Objective:

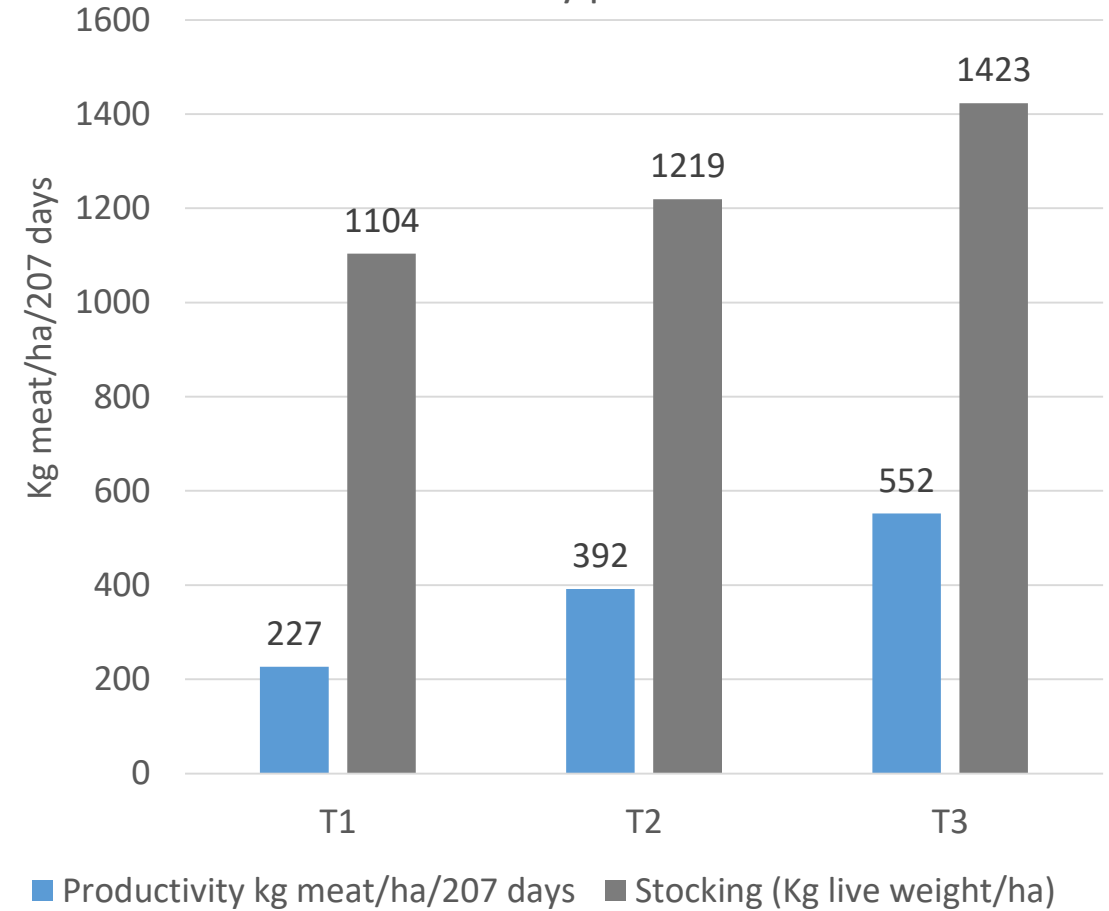
- To determine the weight gain (g/ Animal / day) of steers under grazing in plots with grasses alone and associated with herbaceous and shrub legumes
- Compare traditional management that gives a farmer to his farm vs a Silvopastoral system

Silvopastoral system

Daily weight gain



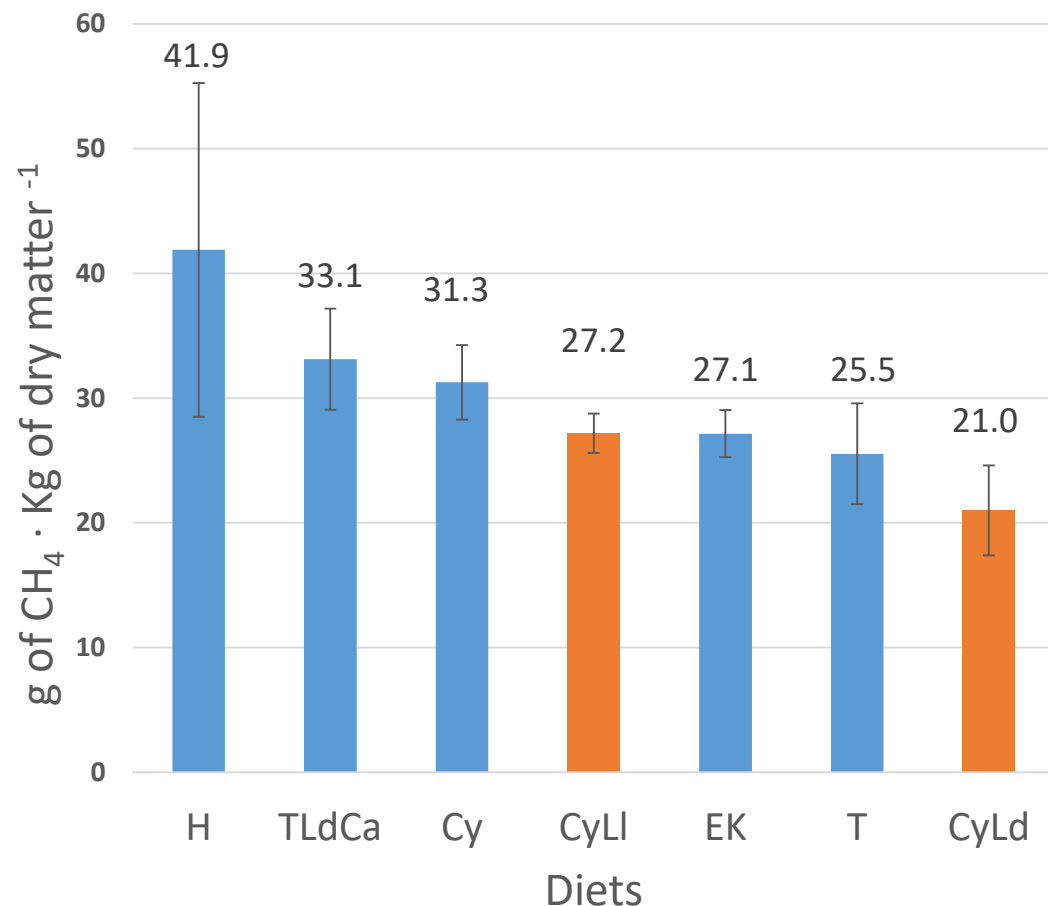
Productivity per hectare



Source: Sotelo & Gutierrez., 2015 m.sotelo@cigar.org

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Enteric methane emissions per Kg of dry matter intake



H: Hay of *Dichanthium aristatum* (Angleton)

TLdCa: *Brachiaria brizantha* cv. Toledo + *Leucaena diversifolia* ILRI 15551 + *Canavalia brasiliensis* CIAT 17009

Cy: *Brachiaria* Hibrido CIAT BR/1752 cv Cayman

CyLI: *Brachiaria* Hibrido CIAT BR/1752 cv Cayman + *Leucaena leucocephala* CIAT 17263

EK: *Cynodon nlemfuensis* (Estrella) + *Pueraria phaseoloides* (Kudzú)

T: *Brachiaria brizantha* CIAT 26110 cv. Toledo

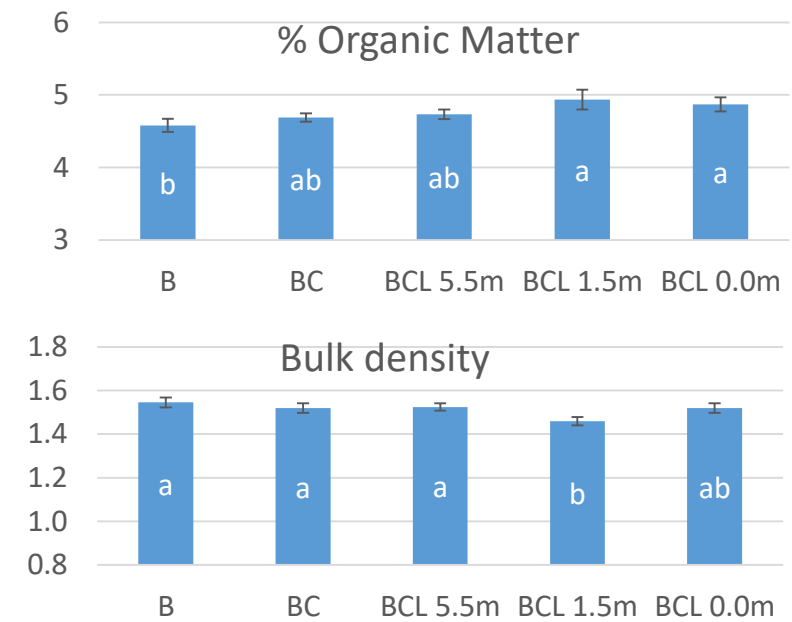
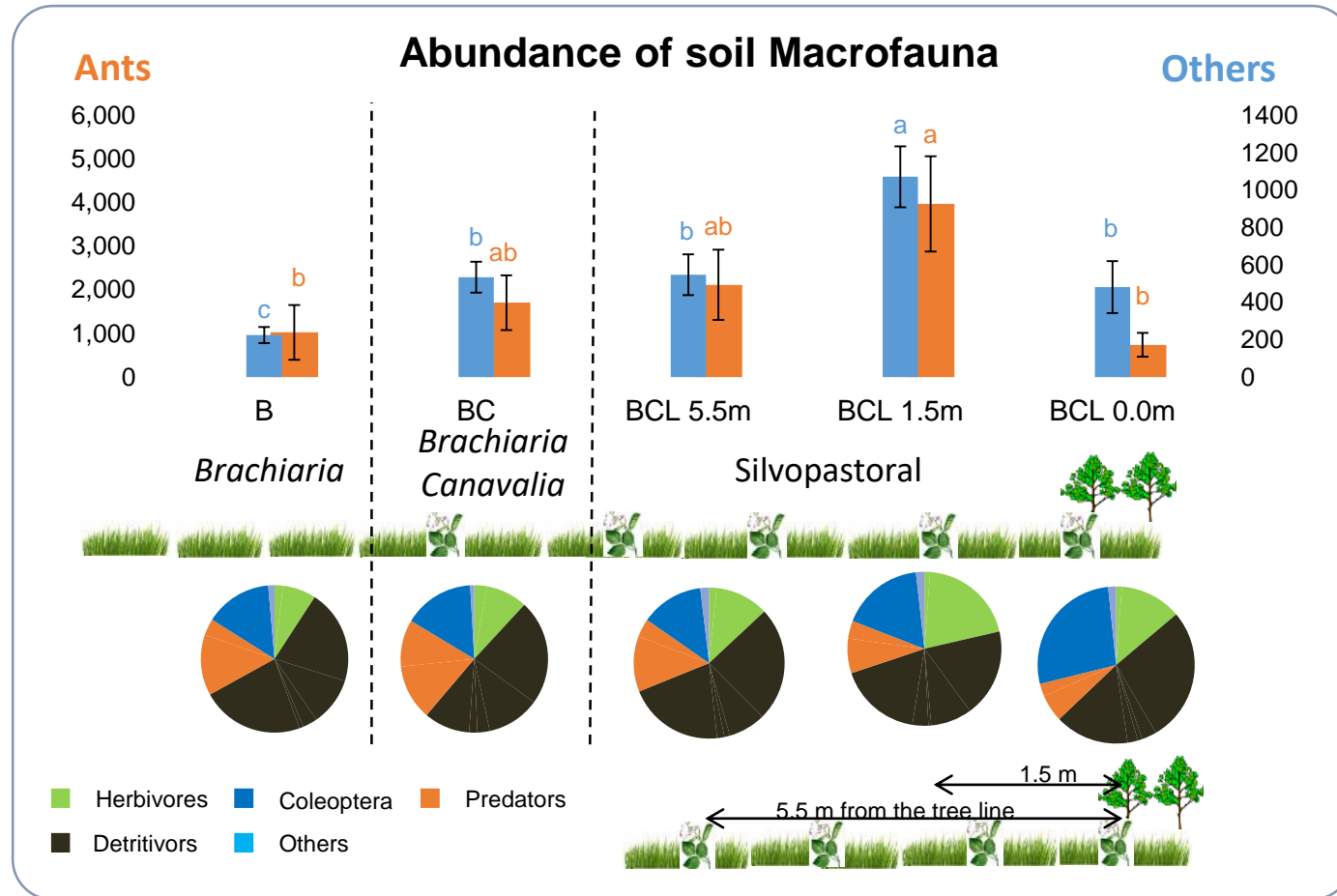
CyLd: *Brachiaria* Hibrido CIAT BR/1752 cv Cayman + *Leucaena diversifolia* ILRI 15551

Animals: 4 Steers of 300 kg in average live weight



Source: Gaviria et al., 2017 Unpublished data x.gaviria@cgiar.org

Ecosystem Services: Silvopastoral systems improve Soil Quality



Biogenic Aggregate

- ✓ The silvopastoral arrangement increased the abundance of **soil macrofauna** and improved soil structure.
- ✓ The biological activity of macrofauna and higher **soil organic matter** found in BCL treatment reduces soil compaction.

Milk production experiment with cows under forage grazing on CATIE Commercial Farm

Under the Livestock Plus (L +) project

Treatments:

- ✓ *Brachiaria* hybrid cv. Cayman in monoculture
 - ✓ Cayman in association with *Leucaena diversifolia*
 - ✓ Cayman in association with *Tithonia diversifolia* + *Arachis pinto*
 - ✓ Cayman in association with *A. pinto*
 - ✓ Control: Current diet is a mix-based of *Brachiaria arrecta* (Tanner) and *Cynodon nlemfuensis* (Star grass) + concentrate
-
- Randomized complete block design (RCBD) with 4 repetitions
 - Repetition area: 2500 m²
 - Treatment area: 1 ha (10,000 m²)



Dairy farming is done on 34 hectares of CATIE's Commercial Farm. CATIE's milk production is an intensive tropical lowland production model whose main objective is to produce quality milk at very low cost with minimal emissions. Today the dairy has a total of 120 milk cows and the milk is sold to the Dos Pinos Cooperative of which CATIE is a member.

Milk production experiment with cows under forage grazing on CATIE Commercial Farm

Response variables at different levels

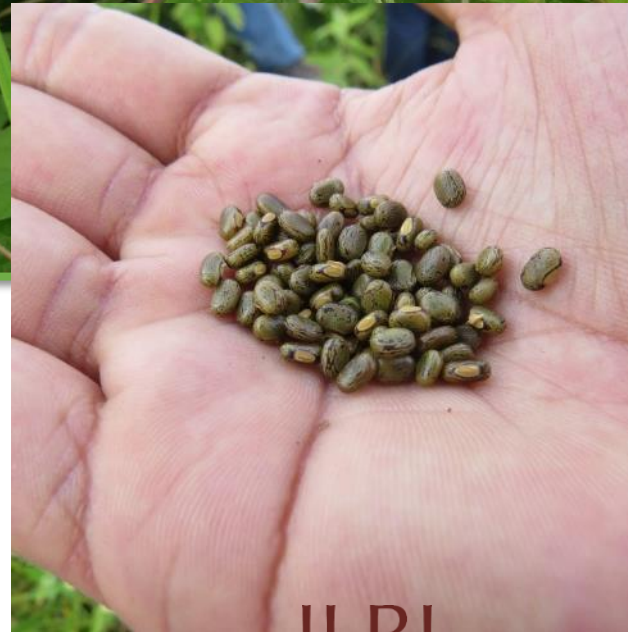
- Forage: ton DM / ha / year, Nutritional quality
- Animal:
 - ✓ kg of milk / cow / day
 - ✓ Nutritional quality of milk: Total solids, Protein, Fat
- Environmental: Emissions of methane at the enteric level
- Soil: Soil health (physics, chemistry and biology), Carbon stock
- Economic: Analysis of the different systems established in the project



Participatory evaluation and dissemination of results



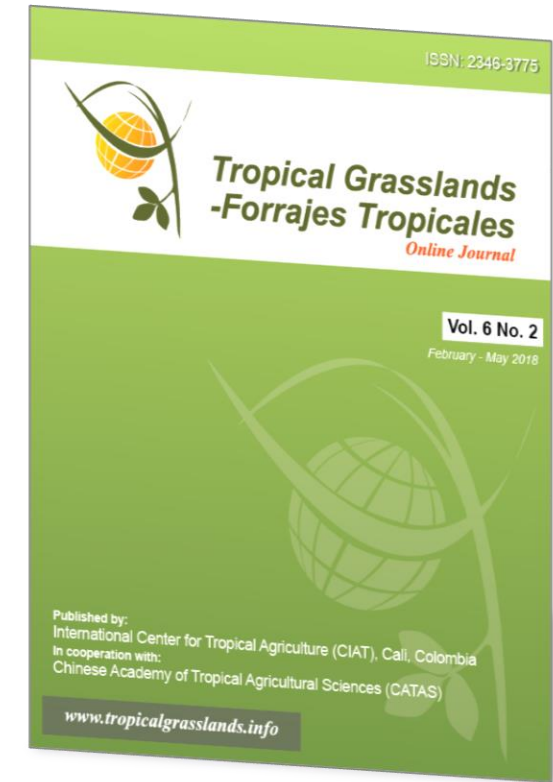
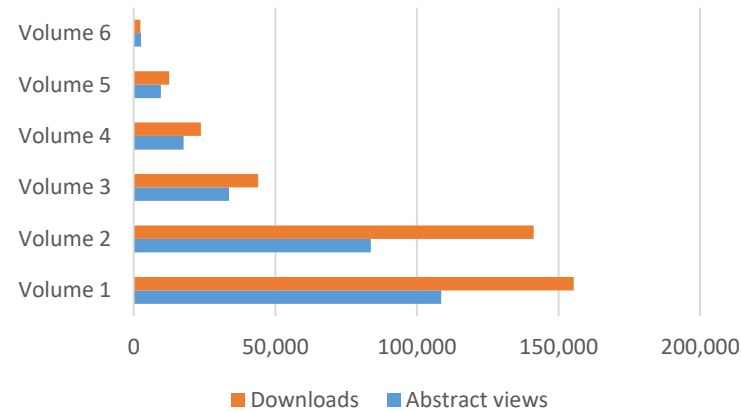
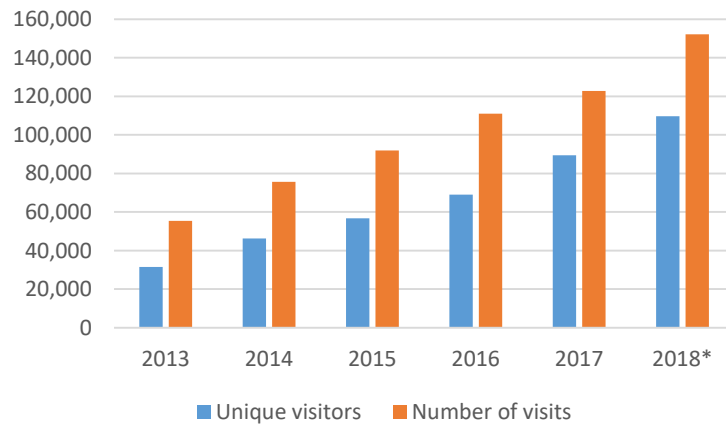
Artisan production of seeds (legumes)



Tropical Grasslands-Forrajes Tropicales Online Journal

ISSN: 2346-3775 www.tropicalgrasslands.info

- An international, open access, bilingual, peer-reviewed online journal
- SHERPA/RoMEO **green** journal [\[+\]](#)
- Released in 2012 as the result of a merger of the former journals **Tropical Grasslands**, and **Pasturas Tropicales**
- 198 papers published so far, 115 in special issues and 83 in regular issues
- Indexed in the major abstract and citation databases for peer-reviewed literature



Impact Factor (2017): 0.389

Scopus CiteScore 2018: 0.63

SciMago Journal Rank (2017): 0.188



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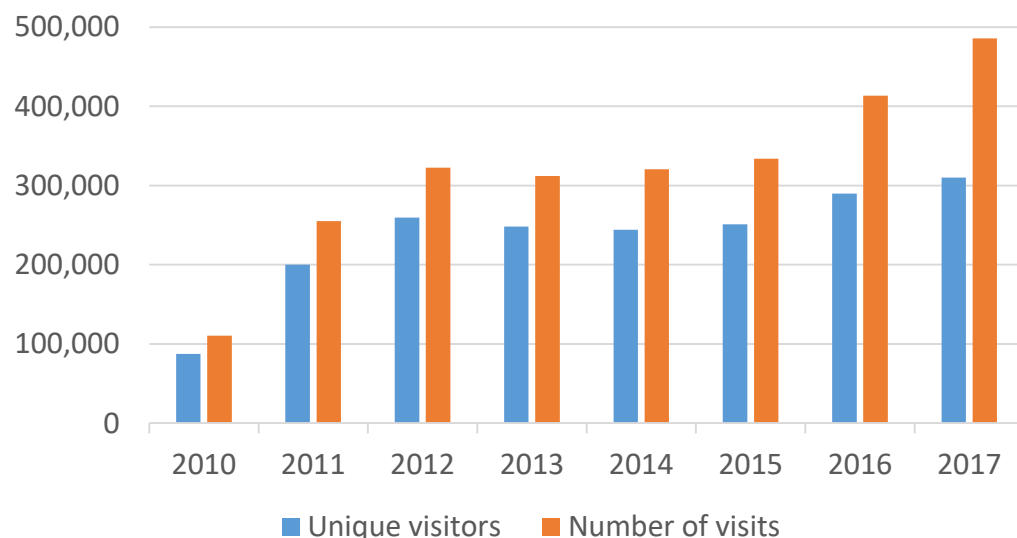
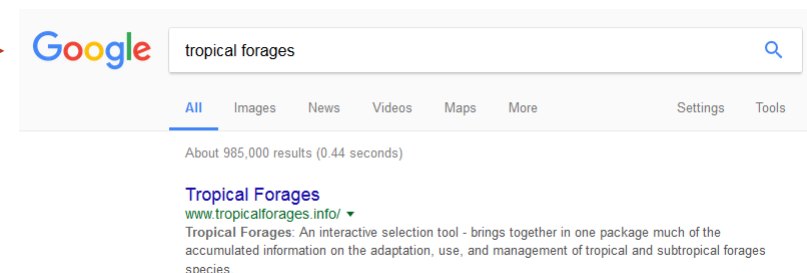


Building a sustainable future



Tropical Forages Selection Knowledge Tool Update

- #1 Result in Web search engines
- Among the most frequented on web site of CIAT; almost 500,000 annual visits
- Preeminent source of information on tropical forages



Update content



Access through mobile devices



Incorporating Advances in IT +



Automatic translation in +90 languages

Partners:



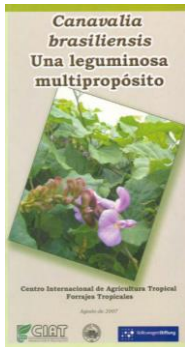
Reference books



Douxchamps, Sabine; Mena, Martín; Van der Hoek, Rein; Benavídez, Alexander; Schmidt, Axel. 2011. **Canavalia brasiliensis** Mart. ex Benth CIAT 17009 : forraje que restituye la salud del suelo y mejora la nutrición del ganado. INTA, CIAT, ETH, Managua, NI. hdl.handle.net/10568/69649



Peters, Michael, Franco, Luis Horacio, Schmidt, Axel, Hincapie, Belisario. 2011. **Especies forrajeras multipropósito: opciones para productores del trópico Americano.** CIAT, BMZ, GIZ, Cali, CO. hdl.handle.net/10568/54681



Franco, Luis Horacio; Peters, Michael. 2007. **Canavalia brasiliensis, una leguminosa multipropósito.** CIAT, Cali, CO. hdl.handle.net/10568/70536



Jones, C. and Sartie, A. 2018. **Opportunities for forage improvement through the ILRI Genebank.** Presented at the Class IV of the University of California, Davis African Plant Breeding Academy Workshop, ILRI, Nairobi, 28 November 2018. Nairobi, Kenya: ILRI. hdl.handle.net/10568/100309

Thank you!



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WE'RE PROUD TO
HAVE CELEBRATED 50 YEARS
OF AGRICULTURAL RESEARCH
FOR DEVELOPMENT

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